Standardized Wideband Data for Target Classification

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LONG TERM GOALS

Generate and distribute data sets to support mine classification algorithm development and evaluation.

OBJECTIVES

The objectives of this task are to:

1. Acquire additional false target data sets and incorporate these data sets into the Standardized Wideband Database for Target Classification, and

2. Generate data sequences for several typical scenarios of a sonar encounter with mines and false targets and analyze these data sets to help establish a baseline for the classification performance achievable by existing or future systems.

APPROACH

Over the last several years, ONR projects have supported the acquisition of highly controlled, wideband target echoes from a variety of bottom mine and non-mine targets. Using the Rotating Seabed facility at Lake Travis Test Station (LTTS), data sets have been acquired for

- 9 bottom mines and 9 (5 new) non-mine bottom targets

- three bottom conditions - smooth sand, rough sand, and gravel

- two ranges - 75 feet and 100 feet

- four depression angles - 3.5, 8.5, 13.5 at 100 feet and 8.5, 18.5 at 75 feet

- two broadband waveforms - 15-100 kHz and 45-200 kHz LFM slides

- one "narrowband" CW pulse - 80 kHz, 0.1 ms

Along with the standard data sets, where the mines are sitting proud on the (Rotating Seabed) bottom, a few data sets have been acquired with targets in non-ideal orientations, e.g., tilted and partially buried.

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Under a previous task, existing mine target and false target data sets were reviewed to assess data quality and the data was pre-processed (beamform, time compress, and time window) to minimize the effect of any acoustic artifacts in the vicinity of the target echoes. The final output of the pre-processing is the target or false (non-mine) target impulse response. Standardized data sets, along with example Matlab scripts for reading the data and generating synthesized echoes for arbitrary transmit waveforms (contained within the frequency band of the original transmitted signal), were distributed to researchers approved by ONR for use in target classification algorithm development.

Under the current task, data sets are being acquired for additional examples of false targets using the Rotating Seabed facility at the LTTS. These data sets will be (have been) processed and included in the Standardized Wideband Database for Target Classification for distribution to researchers as directed by ONR. In addition, the capability is being developed to use combine target/false target echoes derived from the impulse response functions in the Standardized Database with synthetically generated noise /reverberation background data to generate sequences of received echo data representative of typical minehunting sonar encounters with mine targets and/or false targets.

WORK COMPLETED

The current effort year has focused on completing acquisition of false target data sets. Previously acquired false target data sets included:

- a section of concrete pipe,
- a section of a telephone pole,
- a steel drum,
- a single "mine-sized" rock,
- three rocks laid out to be of similar size/shape to a mine,
- two (small and large) lobster traps,
- reef balls, a single reef ball and a group of three, (used to create artificial reefs), and
- a group of four tires.

Additional false target data acquired (being acquired) include an additional grouping of tires as well as a single tire and another grouping of rocks. In addition, partial data sets (e.g., smooth sand bottom only) have been completed so that data has been recorded for both smooth and rough sand bottoms (and a gravel bottom for some targets) for the standard wideband low frequency (15 kHz to 100 kHz) and high frequency (45 kHz to 200 kHz) waveforms and at the usual D/E angles of 3.5, 8.5, 13.5 and 18.5 degrees. Data from these targets have been processed and added to the data sets available for distribution.

Work has continued on the generation of ping sequences to represent typical minehunting scenarios including target and false targets. The Sonar Simulation Toolset software developed by APL/UW was selected as the primary tool for generation of appropriate reverberation background data. This effort has also leveraged work performed for a related ARL:UT task in support of the Submarine Multi-Mission Team Trainer (SMMTT) program under which ARL:UT is generating beam level data required to stimulate submarine sail array sonars. Under the SMMTT effort, bottom mine target data acquired under ONR tasking has been appropriately filtered and injected into synthesized background

data. This framework for injecting target data into background data developed under the SMMTT project has been used to support the generation of echo sequences for this task.

RESULTS

The outputs of the pre-processing steps are illustrated in Figure 1. Figures 1a-1c show waterfall plots of the impulse response function (in dB) for a mine target. In each case, the vertical axis is the ping number, or equivalently, the azimuthal aspect angle of the target, where the target is rotated approximately 0.2 degrees per ping. The horizontal axis is the sample number or time.

Figure 1a shows the impulse response corresponding to a single receive channel. Due to the relatively wide beamwidth of the source, echoes from structures such as the underside of the LTTS barges can be received at approximately the same time as the target echo although these echoes do not arrive from the same angle as the target echo. These artifacts (echoes from something other than the target) appear as the low-amplitude vertical stripes in Figure 1a.

Figure 1b shows the same data after beamforming and shows that the artifacts in the immediate vicinity of the target are significantly reduced. An artifact can still be seen at the right edge of Figure 1b. These echoes are from some structure that is near the same angle as the target but at a different range. As shown by Figure 1c, such artifacts are easily eliminated by applying a simple time window to zero out echoes that arrive at a different time than the target echo.

Figure 2 shows pictures of some the objects selected as false targets and that have been deployed on the Rotating Seabed at LTTS to acquire wideband false target data.

Figure 3 shows an example sonar display resulting from processing synthesized acoustic echo data. Target impulse response data from the Standardized Wideband Target/False Target database was combined with synthesized background data and injected into a sonar processing stream (replica correlation, spatial normalization, and computer-aided detection (CAD). The injected targets have been detected by CAD, although it is necessary to "zoom in" on the picture by ~200% to clearly see the CAD symbols.

IMPACT/APPLICATIONS

The data sets that are being acquired and distributed under these tasks have the potential to support a wide range of Navy research in the areas of mine detection, classification, and imaging. In particular, it is expected that these data sets will be used to support the development and evaluation of mine classification algorithms under the ONR BioSonar program.

RELATED PROJECTS

This task is being coordinated with related ONR D&I projects including the MCM Target Injection task at ARL:UT which developing the capability to inject target/false target data generated by this task into sonar background data recorded at-sea for use in the development and evaluation of automatic detection and classification algorithms.
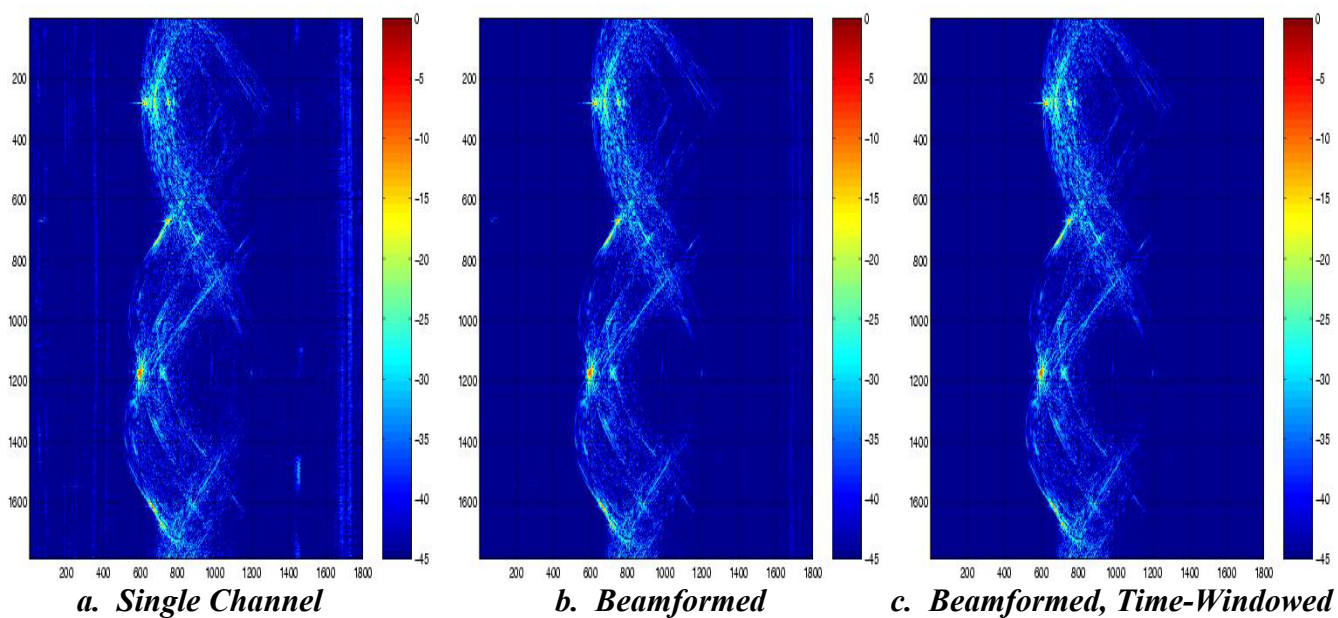
a. Single Channel *b. Beamformed* *c. Beamformed, Time-Windowed*

Figure 1. Example Waterfall Plots of Target Impulse Response Function
[Echo amplitude is color coded; the vertical axis is ping number (aspect angle),
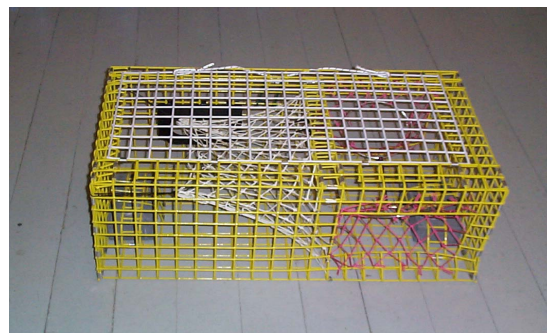*the horizontal axis is sample number (time)]*

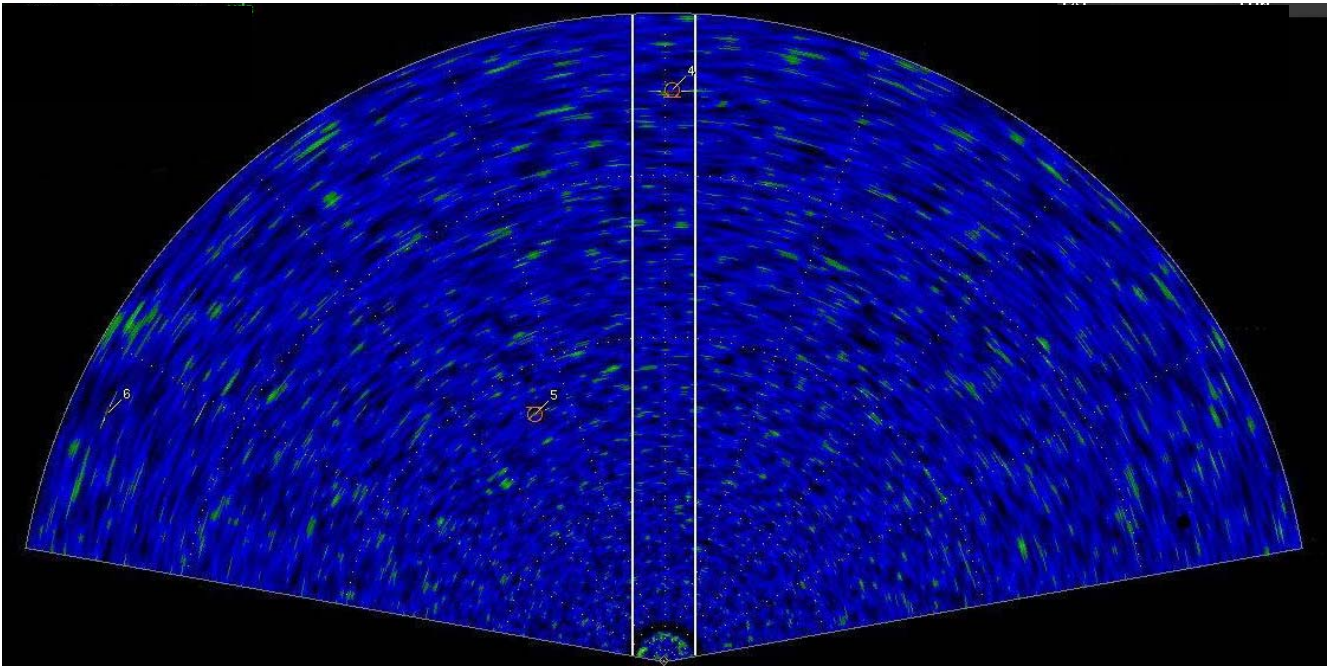*a. Single Big Rock* *b. Three Rocks*

c. Steel Drum *d. Small Lobster Trap*

Figure 2. False Targets: Rocks, Steel Drum and Lobster Trap

Figure 3. Example Sonar Display Using Synthesized Input Data
[Injected Targets have been detected by CAD (markers labeled 4 and 5).]